SIGNALS AND SYSTEMATICS OF JAMAICAN FIREFLIES: NOTES ON BEHAVIOR AND ON UNDESCRIBED SPECIES (COLEOPTERA: LAMPYRIDAE) [1]

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The island of Jamaica is presently credited with at least 50 species of fireflies (McDermott and Buck, 1959), a number that seems truly remarkable when compared with present counts for other areas of similar size. I believe that this is a conservative estimate and that many more are present. In a recent two-week study (16–28 Nov. 1968) I observed the behavior of numerous populations throughout the island and found direct and indirect evidence of the presence of several additional species.

1. *Photinus leucopyge* Barber and *P. melanopyge* Barber: After naming these species Barber (1941) decided they were conspecific and later (McDermott and Buck, 1959) synonomized them. They are distinct morphologically and behaviorally, and are valid species.[3] The signal of *leucopyge* is composed of two rapid pulses although in the field it appears to have 3 or 4 modulations (McDermott and Buck's illustration of this signal, based on visual impressions, shows 4 modulations). It is emitted at intervals [4] of 1.7–2.1 sec (70° F) as the insect flies in rapid and irregular flight 2–4 ft above the ground. Pulse duration is 0.06–0.08 sec and the pause [4] between the two pulses in a signal is about 0.05 sec (71°). Both pulse and pulse-pause duration are more variable than pulse interval, and each pulse has an unusual intensity increment (Fig. 1).

The flash pattern of *melanopyge* is 1–5 pulses, each with a duration of 0.09–0.10 sec and emitted at 0.28–0.30 sec intervals (71°, Fig. 2). The pause between flash patterns is 1.4–1.9 sec. It was probably this species that Seliger *et al.* (1964) recorded and identified as *leucopyge*.

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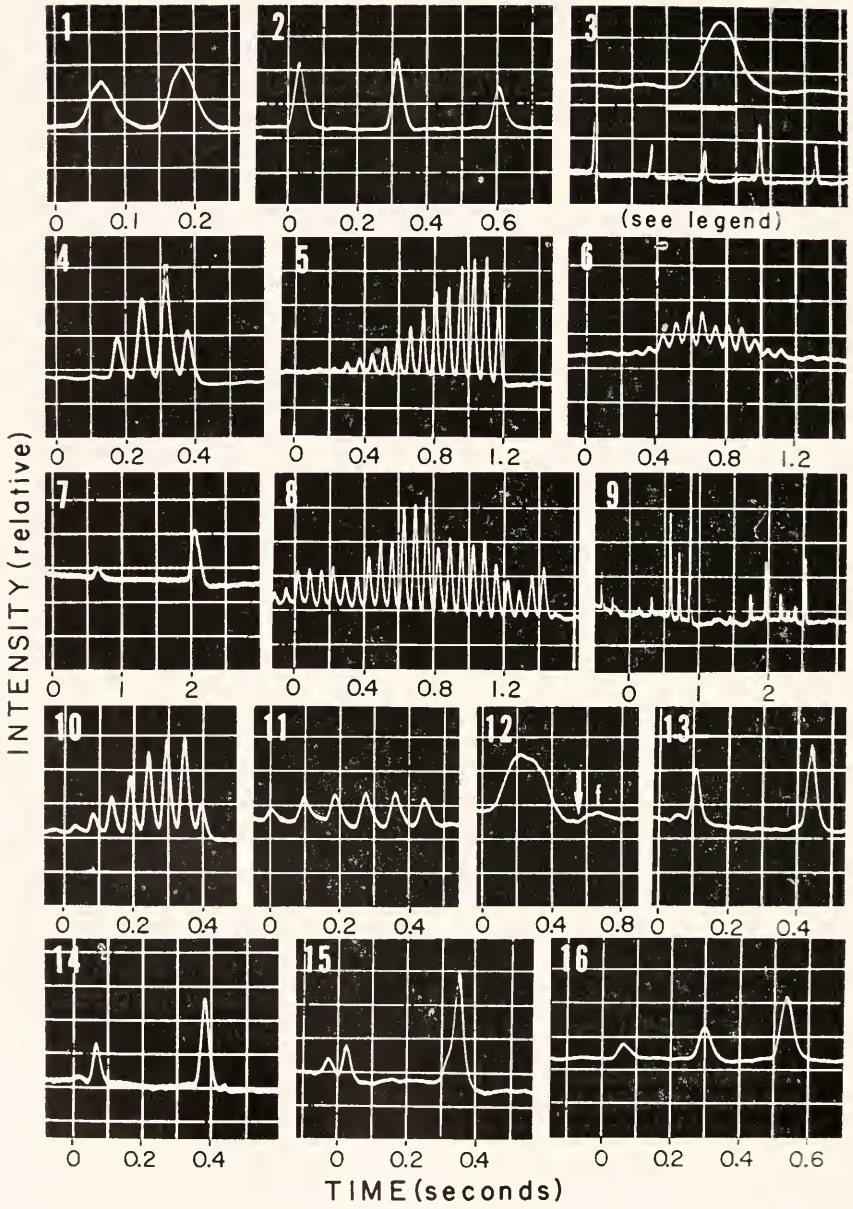
[3] I compared behavior vouchers of *leucopyge* and *melanopyge* with Barber's holotypes. Vouchers of several species have been placed in the collections at Cornell University, the United States National Museum, the Florida Collection of Arthropods, the Museum of Comparative Zoology, and the Institute of Jamaica.

[4] Interval is here defined as the period of time between the beginning of a flash unit (pulse or phrase) and the beginning of the next consecutive unit. A pause is the period from the *end* of one unit to the *beginning* of the next unit.



FIGURES 1–16.

FIGURES 1–16. Oscillograms of firefly flashes; flash patterns of flying males unless otherwise noted. For recording technique see Lloyd, 1968. FIG. 1. *Photinus leucopygo* (71°, Worthy Park). FIG. 2. *Photinus melanopygo* (71°, Ecclesdown). FIG. 3. *Pho-*

Morphologically *leucopyge* and *melanopyge* can be separated with the following couplet:

Ventral abdominal segment 5 with large, white, rectangular or trapezoidal area; pygidium dark.....**melanopyge**
Ventral abdominal segment 5 black or brown throughout; pygidium pale, pale with median infuscation, brown or infuscate with pale areas laterally, or completely dark.....**leucopyge**

2. *Photinus lobatus* Barber was originally described with four subspecies. McDermott and Buck elevated a pale form, *P. l. morbosus*, and *P. l. lobatus*, to species rank and reduced the darkly pigmented *P. l. obscurellus* and *P. l. rapidus* to varieties of *P. lobatus*. I found two darkly pigmented species that morphologically may be distinguished by Barber's couplet (no. 33) that separates *obscurellus* and *rapidus*. For convenience I will use Barber's epithets although I did not compare my vouchers with the holotypes. When the taxon *obscurellus* Barber is formally given species rank the name *obscurellus* will be unavailable because it is preoccupied by *Photinus obscurellus* LeConte (1852). Actually *obscurellus* Barber was a junior homonym when originally published, so the taxon in question has never had a correct name (Lloyd, 1969).

The signal of *rapidus* is a continuous train of single pulses; pulse length is about 0.15 sec and pulse interval 0.83–0.90 sec at 72° (Fig. 3). One courtship was seen in this species. A perched female responded to the flashes of a flying male by flashing single pulses at the rate (occasionally skipping flashes) at which the male flashed and possibly in phase (synchrony) with his flashes. The male swerved in flight and landed 8 inches from the female.

tinus lobatus rapidus (72°, Worthy Park). Upper trace shows enlargement of fourth pulse of lower trace. Time scale: bar indicates 0.1 sec in upper trace, 1.0 sec in lower trace. Fig. 4. *Photinus lobatus obscurellus* or possibly *Photuris jamaicensis*—see text (fourth pulse is distorted, 71°, Ecclesdown). Fig. 5. *Photinus* (midnight) *commissus* (72°, Worthy Park). Fig. 6. *P. commissus* male in spider web (72°, Worthy Park). Fig. 7. *Photinus* near *blackwelderi* (72°, Worthy Park). Fig. 8. Portion of flicker of *Photinus* near *ceratus, morbosus* (71°, Worthy Park). Fig. 9. Landing flashes of male *P.* near *ceratus, morbosus* (72°, Worthy Park). Fig. 10. *Photinus* (18 cps) *evanescens* (71°, Wilmington). Fig. 11. *Photinus* (11 cps) *evanescens* (71°, Ecclesdown). Fig. 12. Flash pattern and female response (f) of perched *Photinus "synchronans"* (71°, Worthy Park). Arrow indicates beginning of female flash. Figs. 13–15. *Photinus amplus* (three different males) (72°, Worthy Park). Each flash is composed of two and sometimes three modulations. The first flash in Fig. 15 could have resulted from a twig momentarily obscuring the flash. The second flash in this signal is unlike the flashes of other individuals recorded. Fig. 16. Portion of flash pattern of *Photinus melanuris* (71°, Ecclesdown). Intensity variation among flashes due to changes in recording distance and flight angle of insect.

Three specimens of *obscurellus* were collected (Ecclesdown). Their flash was a short flicker that *appeared* to have 7–9 modulations and was repeated at estimated intervals of 1.2–1.5 sec. The flicker of another specimen was recorded (Fig. 4) and it had 5 modulations with a frequency of 13.8–14.3 cps (71°). However, this individual could not be collected to verify identification and it is possible that it was instead *Photuris jamaicensis* E. Olivier, a species that sometimes flashes in this manner.

McDermott and Buck report a short, single flash at 2–3 sec intervals for lowland *lobatus* and Seliger *et al.* a four pulse flicker (15 cps) at 1.4 sec intervals.

The color of the elytra in *rapidus* is black and in *obscurellus*, dark brown. As a result, in McDermott and Buck's key the two are separated very early (couplet 24) and *obscurellus* will be identified as *lobatus* but *rapidus* will not.

3. Shortly after sunset in a mature mangrove swamp on the southern coast *Photinus commissus* E. Olivier was seen emitting a flickering flash each 1.7 sec (80°). Flicker and pause durations were similar. Another *P. commissus* began flying and flashing 6 hours after sunset in a sugar-cane field adjacent to a stream and small woods at Worthy Park in the central highlands (1,200'). The flashes at these two localities appeared to be identical, but only those from the highlands were recorded and analyzed. Flicker frequency is 12.7–15.3 cps (10 males, 72°) and each flicker has 13–15 modulations. Modulations gradually increase in intensity during the flash until the last one or two, which decrease (Fig. 5). Flicker interval is 1.8–2.2 sec (72°). The flash of one male was recorded while he was caught in a spider web (Fig. 6) and his flicker frequency was similar to that of free males.

The signal McDermott and Buck associated with *commissus* was a short flicker with 4 modulations in about one-quarter sec. They also noted a seasonal difference in flicker interval and the presence of four genitalic forms. One of these, their illustration No. 99, matches the genitalia of the *commissus* I collected at both localities. Such differences in signals, ecology, diurnal periodicity, and morphology suggest that *commissus* is a complex of species.

4. At 1:30 one morning at Worthy Park, fireflies were flashing near the top of an African Tulip Tree, about 60 ft above the ground. Generally this hour and area of activity would not seem unusual but these fireflies had not been seen previously and subsequent observations disclosed that they did not *begin* activity until about 1:00 A.M.; more than 7 hours after sunset! The signal of these fireflies is composed of two flashes; the second is about 0.25 sec in duration and the first is less intense and perhaps shorter

than the second (Fig. 7). Flash interval is 1.4 sec (72°), and flash pattern interval, 3–5 sec.

These fireflies are similar to *Photinus blackwelderi* Barber in size and coloration but the genitalia are more elongate. Their unusual hour of activity suggests that an earlier-flying species with otherwise similar behavior is present in Jamaica. It would seem that only in the tropics where nocturnal temperatures remain high, could a species confine its activity to the hours after midnight.

5. One Jamaican species emits a signal that is reminiscent of the "tic-tic-tic-buzz" calling songs of the meadow-grasshoppers (*Conocephalus* and *Orchelimum*, Tettigoniidae); 4–8 flashes and then a 1–3 sec flicker. This signal is emitted as the insects fly twisting, downward courses, 1–4 ft above the ground, and 3–6 ft in length. Sometimes the preliminary flashes are omitted, and occasionally two series of flashes are produced before the flicker. Perhaps these function in illumination or inhibit other males from flashing in the immediate area. Because of the variability of the preliminary pulses, and the distance flown during the entire signal, I do not believe they function in sexual communication. Flicker frequency is 13.1–14.9 cps (21 males) and flash pattern interval 10–15 sec at 70–72° (Fig. 8). Landing males emit a ragged series of flashes (Fig. 9).

Morphologically this species is similar to *Photinus ceratus* Leng and Mutchler and *Photinus morbosus* Barber. The genitalia are like *ceratus*'s but the signal is not like that described for either of the above. It is perhaps the same as that given by Seliger *et al.* for "*ceratus-morbosus*." The preliminary flashes (tics) they recorded were short flickers, and they noted the discrepancy between visual impressions and recordings since McDermott and Buck reported unmodulated preliminary flashes in a species in this complex. I did not record these "tics."

6. *Photinus evanescens* Barber is a complex that has been troublesome for taxonomists. Buck (1942) made a statistical analysis of male genitalia and found significant differences among several populations. Barber recognized four subspecies; McDermott and Buck reduced these to varieties. I observed two species in this complex and have been unable to morphologically associate them with Barber's infra-specific categories. Their signals are short flickers that are emitted at 2–3 sec intervals and electronic analysis is usually necessary to distinguish between them. The flicker frequency of one is 18–19 cps (20 males, 71–72°). In each flicker there are 8–10 modulations (Fig. 10). The flicker frequency of the other is 10.5–11.5 cps (4 males, 71°). These signals contain 6–8 modulations (Fig. 11). Seliger *et al.* recorded flickers of 12.5 and 16.7 cps for *evanescens* with 3 and 5 modulations, respectively. Some of my recordings show similar num-

bers and I believe this is because sometimes the recorders failed to detect the dimmer modulations at each end of the signals.

Morphologically the two are distinct and can be separated with the following couplet.

Pygidium pale; tergites pale; sternites 2–4 fuscous; length 6–7 mm. . . . . **18 cps flicker**

Pygidium fuscous or dark; tergites dark; sternites dark; length 7–8 mm. . . . . **11 cps flicker**

7. In most species of fireflies there are individuals whose flash mechanism functions improperly and light is continuously emitted from the lantern. Usually the species-specific flash pattern is superimposed upon this glow. At a site on the southern coast near Morant Bay a number of fireflies were observed emitting light in this fashion. Their glow was brighter than usually observed in aberrant individuals and there was no discernible pattern in the timing of their superimposed pulses. They flew slowly 5–40 ft above the ground while emitting the sputtery glow. Since many were seen behaving in this manner, presumably this is a mating signal. These fireflies are *P. synchronans* Barber on the basis of genitalia (but the tergites are dark rather than pale or light brown, see below). At Worthy Park I found a large population of "*synchronans*" whose behavior was different from that described above. The male flash pattern was a single 0.43 sec flash and its interval was about 3 sec (71°). Courtship was observed in this species. A perched female answered the flash of a flying male with a single flash at a delay of 0.52 sec (Fig. 12). After the third signal exchange the male landed 5 inches from the female and after 4–6 more exchanges reached and mounted her.

Tergite coloration has previously been used as a key character to separate *sychronans* from *melanuris*. While this character is unsatisfactory for separation, they can be distinguished by genitalia (McDermott and Buck), behavior, and the presence of rosy pigment on ventral segment 5. I have been unable to distinguish morphologically between the two "*synchronans*" mentioned above.

Additional Notes on Behavior

The signal of *Photinus amplus* Barber appears to be composed of two flashes and similar to that of the nearctic species *Photinus consanguineus* LeConte. Actually the flashes are bimodal and some may be trimodal (Figs. 13 and 14). The second modulation in most recorded flashes is much brighter than the first, although one recording shows peculiar intensity relationships (Fig. 15); the first flash of this pattern may have been occluded by a twig. Flash pattern interval in this species was 2.8–3.8 sec (72°).

The signal of *Photinus melanuris* Barber is similar to that of *melanopyge* (Fig. 16) but its phrases are composed of 4–11 (rarely 15 or more) pulses. My recordings of this species are similar to that illustrated by Seliger *et al.*

Pyractomena (= *LeConte*a) *gamma* Jac. Duval males emit a three-quarter sec, amber flicker that appears similar to that of the nearctic species *Pyractomena angulata* (Say) in flicker frequency (ca 9 cps), each 1.6 sec of flight (75°). The recordings of Seliger *et al.* for "*LeConte*a," perhaps this species, show a frequency of about 7 cps but the flicker is much shorter. *Photuris jamaicensis* E. Olivier, if it is but one species, emits single flashes, combinations of single flashes, and slow and fast flickers. Females emit flashes when landing as in nearctic *Photuris* (Lloyd, 1968) and are probably also aggressive mimics; one ate a *Photinus* male that was caged with her (T. J. Walker, pers. comm.) and another was observed repeatedly answering the flash pattern of a *commissus* male. *Photinus pallens* Fabricius (coastal, near Negril) emits phrases composed of 1–6 (3 most frequent) (fused?) pulses at 6–10+ sec intervals. In multipulse phrases, pulse intervals are 0.2–0.3 sec and each pulse is brighter than previous ones in the same phrase. This species is sedentary, and lengthy periods of perched flashing occur between flights. *Robopus* (= *Diphotus*) *montanus* Barber is also sedentary and both males and females emit continuous glows while perched. The glow of one male was recorded and was without high frequency modulations.

Flashing activity in the following species begins 15–35 min after sunset; *evanescens* (both species), *leucopyge*, *commissus* (Milk River, mangrove), *melanuris*, *Pyractomena gamma*, and *Photuris jamaicensis*. Worthy Park *synchronans* started 90 minutes after sunset and a single flash, upland *pallens* began one hour after sunset.

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The Entomologist's Record

To encourage the publication of concise and useful new distribution records, corrections of previously published erroneous records, misidentifications, short field notes, and current news items about entomologists, amateur and professional, entomology departments and museums, prompt (monthly) publication is offered in this department.

New Synonyms of *Asphondylia betheli* Cockerell (Diptera: Cecidomyiidae).—Two papers have recently appeared which concern, at least in part, the biology and the effect on prickly pear cactus of the western North American gall-midge, *Asphondylia betheli* Cockerell, 1907. These are by M. N. Ganz on ovule abortion and fruit proliferation instigated by this gall midge on *Opuntia macrorhiza* Engelm. (Cactaceae) (1968, Cactus & Succulent J., Cactus & Succulent Soc. Amer. 40(6): 249–252) and by J. Mann on cactus-feeding insects and mites (1969, U. S. Nat. Mus. Bull. 256: x & 158 pp.) In the latter, the name *Asphondylia opuntiae* Felt, 1908, is used instead of *A. betheli*, and both papers note the fact that three species of *Asphondylia*, the two aforementioned species and *A. arizonensis* Felt, 1907, are recognized as occurring on *Opuntia*. Felt (1908, N. Y. State Mus. Bul. 124: 377; 1916, *ibid.*, 186: 116) separated his two species from *A. betheli* on the basis of an alleged difference in the number of palpal segments and from each other on the basis of color differences. I have seen the type series of all three species and find that each specimen has three-segmented palpi. The short first segment is almost hidden from view in the slide preparations of *A. betheli* and is presumably the reason Felt counted only two segments. The color of the insects is not of specific value as it is usually a function of the time the sclerites are allowed to harden and darken after eclosion before the insects are killed. No other differences on which to separate these three taxa are apparent, and I am here synonymizing *A. arizonensis* and *A. opuntiae* under *A. betheli*. The description of *A. betheli* (1907, Can. Entomol. 39(9): 324), which appeared IX-16-1907, antedates that of *A. arizonensis* (1907, *New Species of Cecidomyiidae II*, Albany, N. Y., 23 pp.) which appeared X-26-1907.—Raymond J. Gagné, *Systematic Entomology Laboratory, Entomology Research Division, c/o U. S. National Museum, Washington, D. C. 20560.*